Understanding High Temperature Mobility of Radiogenic Pb in Zircon

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Zircon is a widely used mineral chronometer which utilises the U-Pb decay system. Mobility of radiogenic Pb in zircon at high temperature however, may produce anomalous data, leading to erroneous age calculations. Here we present SIMS, LA-Q-ICPMS, CL, Raman and EBSD data from zircon separated from the Archean granulite facies Lewisian Gneiss Complex of NW Scotland in order to better understand processes leading to high temperature mobility of radiogenic Pb in zircon.

CL and Raman images reveal a complex poly-phase zonation, with up to four separate domains visible from a single zircon. Dark CL cores correspond with increased Raman line broadening and shifts of phonon frequencies, consistent with an increasing radiation dose. Conventional SIMS spots yield an unusual age distribution with older $^{207}Pb/^{206}Pb$ ages recorded in external domains and younger $^{207}Pb/^{206}Pb$ ages evident from core regions. Rapid LA-Q-ICPMS mapping was used to generate two dimensional U-Pb and Pb-Pb age maps, as well as REE and calculated α-dose maps. U-Pb and Pb-Pb age mapping of grains demonstrates decoupling of ages from REE and CL maps and provides high-spatial resolution evidence that Pb has been mobilized. CL, Raman and REE maps rule out the possibility that Pb was mobilised by wholesale recrystallization during metamorphism. Calculated α-dose and Raman maps indicate areas which have suffered moderate to high radiation damage have lost Pb to surrounding regions of low α-dose.

The pristine nature of the surrounding lattice material cannot account for acceptance of Pb by means of plastic lattice distortion or radiation damage. The only remaining known mechanism that can explain the decoupling of chemical zoning and $^{207}Pb/^{206}Pb$ ages is volume diffusion of radiogenic Pb through the pristine zircon lattice.